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Requirements for Standards and Commonality with Regard to Knowledge Based Systems for Coalition Operations

Alice M. Mulvehill
BBN Technologies
10 Moulton Street
Cambridge MA 02138 USA
amm@bbn.com

Ted Kral
BBN Technologies
9655 Granite Ridge Drive, Suite 245
San Diego, Ca. 92123 USA
tkral@bbn.com

Abstract

The theme of the paper is: what is the impact that knowledge based systems for Coalition Operations have on the requirement for standards and commonality? Do knowledge based systems mitigate or compound the need for standards? The authors have fifteen or more years of experience in research and development of knowledge based prototype systems for use by diverse groups and virtual organizations. In all these initiatives, the degree and type of standardization became an issue. There were various approaches taken to satisfy the need and/or desire for standards, such as, common environments, common plan representation, common planning process, common hardware, common user, etc. The paper presents the authors' view on several of the techniques used, lessons learned, and the applicability to the domain of Coalition Operations. Insights are also provided into cognitive issues based on culture with regard to terminology, training, operational concepts and planning processes.

Introduction

It is not our intention in this paper to debate the issue on whether the use of standards is good or bad nor whether they are necessary or not in the development of computer software. Our intention is to report on the role that standards played in several major decision support programs and the relevance to knowledge based systems for Coalition Operations.

BBN Technologies has done extensive work in the area of communication, crisis planning, transportation and information assurance. BBN Technologies has developed a number of knowledge based decision support systems to support the various aspects of military planning. Our expertise includes the design and development of independent systems as well as the integration of heterogeneous systems in support of military exercises and/or demonstrations. In addition, our support of demonstrations like the Joint Warrior Integration Demonstration (JWID) have stressed intercommunication between disparate systems, collaboration among distributed planning teams, data sharing in multi-security environments, and planning coordination with coalition partners.

In our experiences, there have been efforts to provide some standard platforms, common operation infrastructures, and common terminologies in order to facilitate communication

and collaboration in a distributed environment. The role of these standards ranged from the provision of linkages between two disparate systems through the usage of mapping tables to the development and usage of common schemas (plan representation), common planning workflow processes, and common ontologies. Figure 1 suggests that there exists a correlation between the degree of closeness between two entities (be they human or software system) and a tendency to share a common terminology. For example, when two systems, developed by separate contractors need to communicate, a simple mapping table like the one provided in Table 1 can be used to bridge the gap between the terms used to refer to a concept or process in one system with the terms used to refer to those same concepts or processes in the other system. This method works well when the two systems do not need to (or do not believe that they need to) communicate or collaborate often. As the need to work together increases, so increases the need for a more standardized and extensive communication environment.

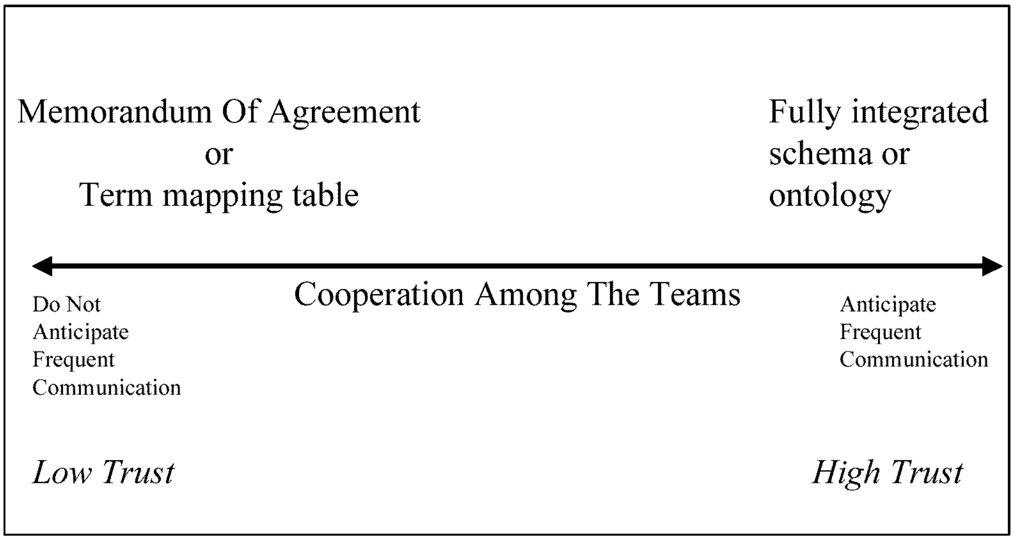

Figure 1 – Communication Continuum

The ARPA/Rome Lab Planning and Scheduling Initiative (ARPI) Experience

This was a large Joint DARPA and Rome Laboratory initiative stretching over more than five years. It also involved a large number of prominent researchers and organizations in the field of planning and scheduling. As such we could not due justice in the space allotted to fully report on this effort. Instead those interested readers are directed to the reference article by Austin Tate (Advanced Planning Technology, Technological Achievements of the ARPA/Rome Laboratory Planning Initiative, AAAI Press, 1996).

Points to be stressed are that this initiative did explore many aspects of the planning domain and the supporting technologies including standards. Effort was devoted toward the development of a common environment to conduct experiments. Emerging from this were concepts of Technology Integration Experiments (TIE) and the process of the Integration Feasibility Demonstrations (IFD). Additionally, there was a considerable amount of effort applied to the selection of standards and common tool use to promote

interoperability between various technologies used for automated and semi automated (mixed-initiative) planning (user in the loop). One significant pursuit that this program devoted a significant amount of program time and resources to was in the development of a "Common Plan Representation".

The Joint Task Force Advanced Technology Demonstration (JTF-ATD) Experience

This again was a significantly large effort for which we could not due justice in describing in the space allotted. Again, *references* are provided at the end of this paper for those interested in gaining more insight into this initiative. The program was intended to capitalize on the results of the ARPI effort and to develop a distributed planning environment based on a linkage of supporting functional planning cells called anchor desks and the operational planning cell. While the ARPI initiative explored standards and basically followed a "de facto" standards policy, the JTF-ATD effort stressed the enforcement of standards centered around the CORBA technology and the concept of a series of web based object servers. The intent was to separate application development from concern regarding the mechanics of interoperability and accomplish that through the use of servers with a common interface and schema. This effort also pursued the

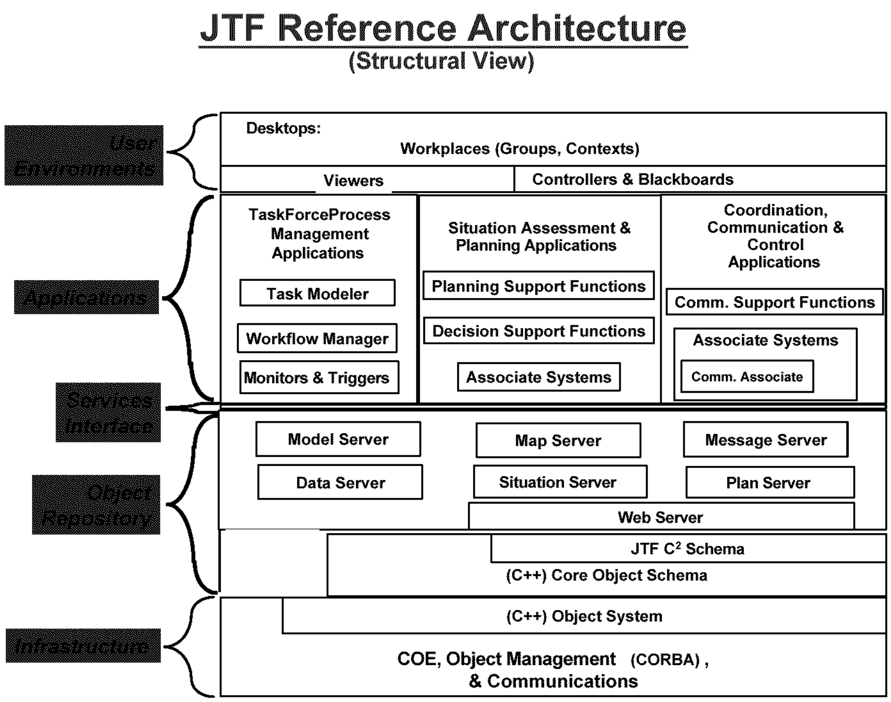

Figure 2 - JTF ATD Reference Architecture

development of a common plan representation in the form of a common plan object. A considerable investment of this program was devoted to training individual development groups on the standards and also enforcement of these standards when software was delivered. Figure 2 is a graphical representation of the JTF Reference Architecture standard.

The ACOA Experience

Since this is a more recent program and supposedly builds from lessons learned from previous endeavors, we will spend more time on this experience. BBN was one of the key developers of components of the AITS-JPO Adaptive Course of Action (ACOA) ACTD. The goal of ACOA is to demonstrate advanced technology to help develop multiple deployment scenario courses of action. The objective of ACOA is to include its capabilities under the Global Command and Control System (GCCS)

The ACOA ACTD is based on a user-centric, iterative development philosophy, following a rapid application software development lifecycle. The primary user is located in USPACOM and provides operational feedback on ACOA capabilities. ACOA has been tested for military utility as part of military command post exercises—the most recent during Ulchi Focus Lens 01.

The ACOA ACTD (see Figure 3) consists of several integrated knowledge based tools, including: The WebPlanner, for which BBN is the prime developer, is an integrated system that includes the Operations Planning Tool (OPT), Course of Action Selection Tool (COAST), Force Management Tool (FMT), Joint Assistant for Deployment and Execution (JADE), and TURBO PLANNER. OPT provides planning process templates used to assemble and share

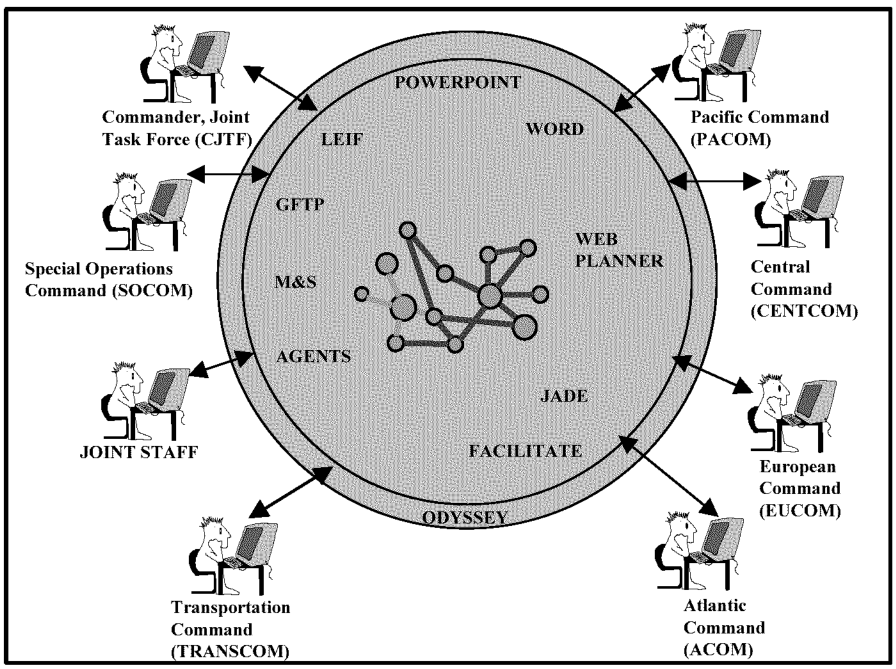

Figure 3 – Collaboration within the ACOA Environment

critical plan information and generate key military plans, orders and messages. COAST employs fuzzy logic technology to assist in developing and comparing alternative courses

of action. FMT adds capability to identify ready and available forces, task organize forces to specific missions, specify deployment destinations, and time-phase forces for deployment. JADE provides a suite of tools to match specific force capabilities with required tasks and quickly generate time-phased force and deployment data using pre-defined force packages and "Drag-and-Drop" technology. In ACOA, these tools can be operated by multiple distributed planners via the Campaign Object Schema.

To illustrate how the needs for two systems (or human planners) can change over time, we will now describe how the interoperability of two of the ACOA components (The WebPlanner and JADE) evolved over time. Both of these systems were involved in a previous Technical Integration Experiment (TIE) during the DARPA ARPI program under their previous names of Target and ForMAT. In the ARPI TIE, while there was not any anticipated notion that the two systems would communicate with each other on any regular basis, the TIE was intended to allow the system Target to make queries against the ForMAT system for information about how forces were deployed in previous, but similar planning contexts. Table 1 shows a piece of the data mapping table that was established by the developers in order to allow these two systems to communicate. The term on the left is the term used in Target, and the term on the right is what that concept is called in ForMAT. The data mapping table was required because neither system was inclined to change its terminology.

("OPERATION NAME" mission)
("AREA OF RESPONSIBILITY" geographic-location)
("SUPPORTED CINC" theater)
("FORCE CAPABILITY" function)
("FORCE SERVICE" service)
("FORCE UIC" uic)
("A" army)
("F" air-force)
("M" marines)
("N" navy)

Table 1 – Term Mapping Table

During ACOA there was a requirement for all systems, including the WebPlanner (the successor of Target) and JADE (the successor of ForMAT) to collaborate with each other using a common schema and a common Campaign Object Server. Iinstead of a data mapping table, common data is stored in the ACOA Campaign Object for use by any tool that understands the Campaign Object Schema. Figure 4 illustrates how JADE uses this

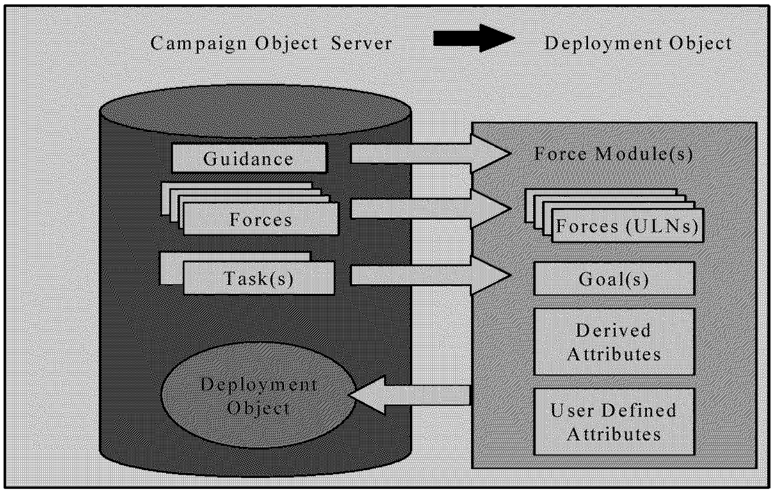

Figure 4 – Deployment Plan Development and The ACOA Campaign Object Schema

data to develop the Deployment Plan. You will still notice that a few term inconsistencies still exist, e.g., between tasks and goals. This means that the JADE system has to do some of its own translation in order to maintain its own processing capability while interacting with others. We believe that there are lessons to be learned from the communication history of these two systems that will apply (by analogy) to multi-national coalition team formation and development

Using Ontologies

The data mapping table in Table 1 is a simple instance of ontology mapping. Ontologies are being developed as part of the DARPA DAML (Darpa Agent Markup Language) program to better enable software agents to read text. Software agents and agent teaming methods are being developed as part of the DARPA CoABS (Control of Agent Based Systems) program to allow for the rapid formation of mixed-initiative agent based systems in response to some crisis or threat (for more information, see Burstein, M., Mulvehill, A., and Deutsch, S. 1998). BBN is involved in both of these programs. BBN is the integrator for the DARPA DAML program where researchers are developing ontologies and tools that allow for mappings between ontologies. The ontology mapping will allow for the development of shared ontologies and common operating environments where software systems, software agents, and the human users of those systems can preserve their own terminological preferences while still communicating with others.

Our experience to date in the the CoABS and DAML programs leads us to suspect that multi-national coalition teams will require the establishment of some standard operating ontology and that ontology mapping tools will be required in order to facilitate the entry of new players into a forming coalition. We believe that the entry of new members to an existing Coalition is analogous to how ForMAT and Target worked, e.g., members of the team develop very defined expectations of what other members of the team will do. But

just as the ForMAT/Target relationship evolved, so too will coalition teaming arrangements. Perhaps ontological mapping tools can facilitate that evolution.

Forming Coalitions -- Lessons Learned from JWID

A Joint Warrior Integration Demonstration (JWID) is a means to bring together multiple systems to test how well they perform together to support some planning scenario. While BBN has been involved to some extent in may JWIDs, two of the JWIDs which could provide valuable lessons learned for coalition formation were JWID-94 and JWID-95.

One of the prime objectives of JWID-94, (Figure 5),was to show evolving processes and technology for distributed collaborative planning (DCP) and how DCP tools could be used to support deliberate as well as crisis action planning for a Joint Task Force (JTF) deployment. Systems and networks that support and enhance the communications infrastructure for the JTF operation, including multi-level security were also tested.

During JWID-94, a disaster relief scenario and a combat operations scenario were used to test the usage of several tools, technologies, and systems, including: Tachyon, Advanced Planning System (APS), Force Level Execution System (FLEX), Weather Anchor Desk, Air Campaign Planning Tool (ACPT), Theater-Level Analysis Replanning Graphical Execution Toolkit (TARGET), Cronus, Force Management and Analysis Tool (ForMAT), Analysis of Mobility Platform (AMP), In-Theater Airlift Scheduler (ITAS), Rapid Application of Air Power (RAAP), Web Authoring and Management System (WebMan), The Logistics Anchor Desk (LAD), and the Targeting Management System (TMS)). For this JWID, the BBN system TARGET was used as the distributed toolbox and environment for collaboration.

The following excerpt is from the conclusions and recommendation sections of the JWID94 final report with regard to the results obtained from this exercise:

> "Tools and architecture for planning military and non-military responses to crisis situations were well represented and showed their value added in the Joint Task Force environment. The TARGET system, (Figure 6), used a shared database as a common point for planning, which thereby provided its value as a tool for organizing, weighting, and reviewing assumptions, planning factors, rationales, etc. that are used by the staff in formulating recommended Courses of action. The Air Campaign Planning Tool (ACPT) generated an Air Campaign Plan, sharing its data with TARGET and its resulting Candidate Target List (CTL) with the Rapid Application Air Power (RAAP) tool. The tools most preferred for use during DCP were video, voice, briefings, and pointers. Conferencing sessions were very successful in demonstrating the effectiveness of using distributed networking, COTS collaborative planning software, security guards, and Video Teleconferencing in concert to create a powerful conferencing environment. This capability is particularly valuable in the area of crisis management, where problems can be ill-defined, accurate situation assessment critical, and clearly communicated consultation of prime importance. Collaborative planning has

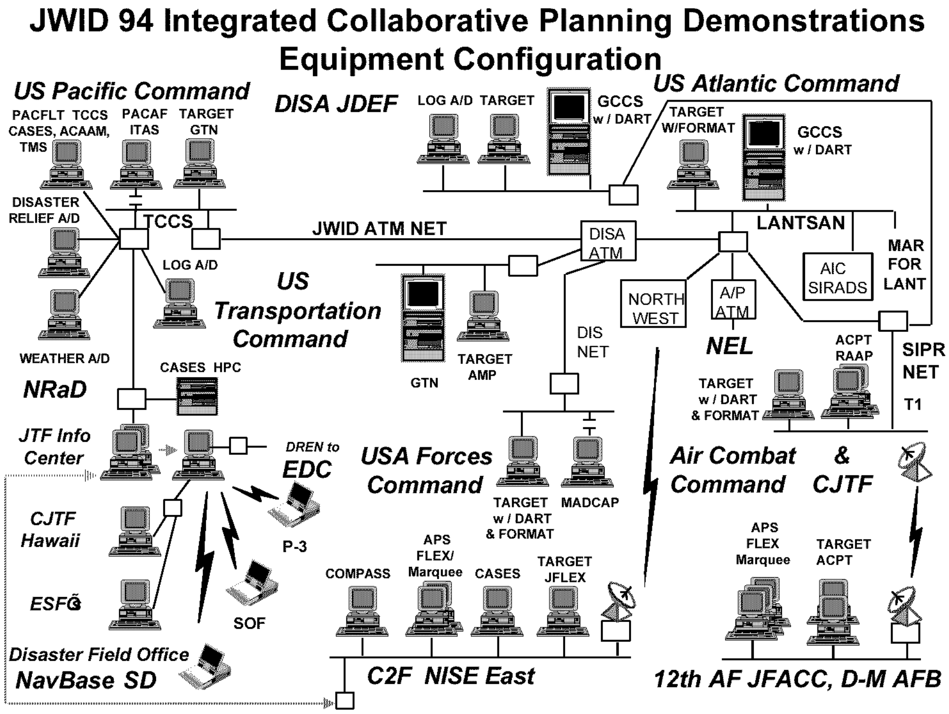

Figure 5. JWID 94 Configuration

Figure 6. Theater Analysis , Replanning, and Graphical Execution Toolkit (TARGET)

useful functions to make planners more systematic and objective in their planning. Additionally, the ability to share the thought process with other agencies can be a plus, provided developers implement protocols to prevent database corruption and input/output saturation.

In summary, JWID-94 results illustrated how the following factors affected distributed collaborative planning and interoperability:

- platform
- speed and efficiency of I/O between functionally related systems
- the impact of the network type on intercommunication
- the impact of environmental issues on interoperability
- collaboration between systems and among geographically distanced sites
- human collaboration techniques
- skill level of the operator." (Defense Information Systems Agency, 1994)

Could any of these lessons learned be used to develop a set of standards that could be used to support multi-national coalition formation and development?

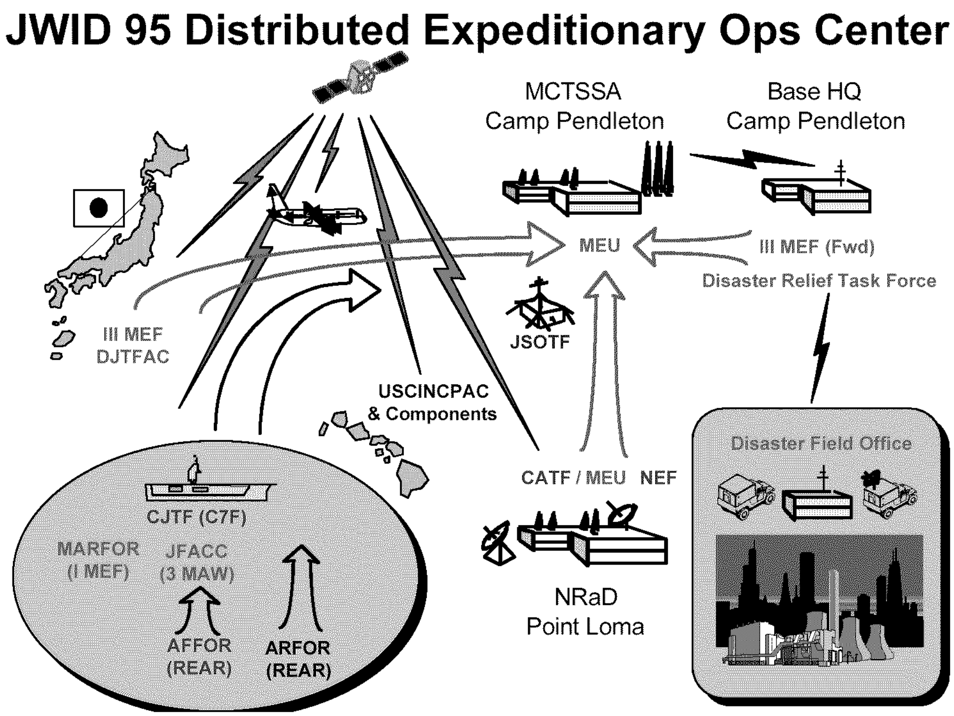

Figure 7. JWID 95 Configuration

JWID 95 (Figure 7) conducted in the subsequent year attempted to probe these areas. The following excerpts are from the final report:

> "Several overarching technology areas demonstrated in JWID 95, are changing the way that the Warfighter will share, access, process and disseminate information. World Wide Web (WWW) technology was used extensively to enhance information exchange and access. Collaborative planning tools such as whiteboards, shared applications, and on-line chat functionality provided low bandwidth solutions to sharing and collaboration. Anchor desks used these collaborative capabilities to support functional areas however, a COE is needed to enhance interoperability. For JWID 95, the Joint Staff, J6, extended an invitation to the member nations of the Combined Communications Electronics Board (CCEB) to participate. This invitation was accepted by Australia, Canada, and the United Kingdom. New Zealand, the remaining CCEB nation, initially planned an active role, but ultimately participated only as an observer. Three principle objectives for Allied involvement were accomplished during JWID. They were:
>
> - Receipt and display of US Common Operational Picture (COP).
> - Participation in the development and distribution of the US ATO.
> - Participation in the course of Action (COA) development through Distributive collaborative Planning sessions.
>
> The recommendations regarding Allied Participation, based on the JWID95 experience were that CONOPS should be developed, based on CINC requirements, for releasability of classified information to Allies. Appropriate JTF architecture documents and focus on the doctrine process, procedures and MLS systems should be provided to each participant. "(Defense Information Systems Agency, 1995)

Could any of the lessons learned from the JWID95 experience, particularly with Allied participation be used to develop a set of standards that could support multi-national coalition formation and development?

Forming Coalitions – Cultural and Social Issues

In forming a coalition, a human planner, along with his/her computing hardware and software, and perhaps software agents, will be invited to join a coalition team. The new member should be provided with a an API, process model, and some specified set of communication terminology. The size of the communication terminology provided could be based on how similar the new member is relative to existing team members. Similarity can be assessed in terms of: culture, technological sophistication, planning style, and social practices. If the new member is very similar, than he/she may be presented with a common ontology or schema. If the new member is very different, then mapping tables may need to be defined to allow them to map from their terms to the terms of the rest of the coalition.

Work by Hofstede (Hofstede, Geert, 1997) suggests that the similarity between planners from different countries can be determined from a set of dimensions. The work of Hofstede and of others like Marcus et all (Marcus, A. and Gould, E.W., 2000) who have used Hofstede's work to provide directions on how user interfaces should be designed, suggest that there is a correlation between dimensional ratings and communication and collaboration style. Perhaps, new potential coalition members can be evaluated using this method, and communication and collaboration mechanisms determined based upon their scores.

Conclusion

If one draws an analogy between the methods required to link computer systems and applications together to the methods needed in order to link multi-national human planners together, then the lessons learned from an attempt to link a number of heterogeneous systems together to participate in the programs we described in this paper can be used to support the development of multi-national coalition teams. Additionally, the use of standards appears to be related to the interoperability one desires in the functionality or the operation of the software applications. Another factor is whether or not the concept of development involves the independent development of heterogeneous components which are then integrated as pieces to form larger integrated software applications or systems.

In summary, it is the opinion of the authors that the use of knowledge based systems does not make the issue of standards any more demanding than does the development of software in general. With regard to mitigating the issues of standards we see no current conclusive proof based on our observations and involvement in software development to indicate that the use of knowledge based systems in coalition operations does or does not make the requirement for standards and commonality any less. In fact the determining fact is more driven by other functional factors than the technology methods employed in development. The degree of standard requirements seems directly related to the degree of interoperability and integration desired. The impact is also determined on whether or not management attention is given to standards and the defining of the desired role in the initiative. In other words, standards can have as big as an impact as you desire. However, our recommendation is to adhere to a "minimum essential" policy with respect to standards placed on software systems. We have further observed that it is best to address the area of standards at the beginning of a program and not to ignore the issue or attempt to retrofit later.

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